

04259.P007

Patent

UNITED STATES PATENT APPLICATION

for

MULTIMEDIA AND COMPUTING SYSTEM

INVENTOR:

Steve Perlman

Prepared by:

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN, LLP  
12400 WILSHIRE BOULEVARD  
SEVENTH FLOOR  
LOS ANGELES, CALIFORNIA 90025  
(408) 720-8598

Attorney's Docket No. 04259.P007

"Express Mail" mailing label number EL627465313 US

Date of Deposit Sept. 7, 2000

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Cindy Murphy  
(typed or printed name of person mailing paper or fee)

Cindy Murphy  
(Signature of person mailing paper or fee)

001000 "4955960























FIG. 6c illustrates one embodiment of the system for tuning between multimedia channels.

FIG. 6d illustrates one embodiment of the system for playing a CD jukebox.

5        FIG. 7a illustrates one embodiment of a home media server for coordinating between standard telephone services and IP telephone services.

FIG. 7b illustrates one embodiment of a software architecture for implementing standard telephone, IP telephone and/or video conferencing.

10       FIG. 7c illustrates a signal diagram of communication between a home media server and telephone.

FIG. 8a illustrates a home media server coordinating between standard broadcast channels and packet-switched channels (e.g., the Internet).

FIG. 8b illustrates a potential progression of bandwidth allocation between packet switched channels and analog/digital broadcast channels.

15       FIG. 8c illustrates multimedia buffering according to one embodiment of the invention.

FIG. 9a illustrates a histogram showing a normalized bitrate for a particular multimedia stream.

20       FIG. 9b illustrates one embodiment of a system for intelligent bandwidth allocation and buffering.



FIG. 9c illustrates bitrate data normalized at one second intervals.

FIG. 9d illustrates bitrate data for three separate multimedia streams normalized at 10 second intervals.

FIGS. 9e-m illustrate histograms of normalized bitrate data for various  
5 DVDs.

FIG. 10 illustrates a cable television module according to one embodiment of the invention.

FIG. 11 illustrates a satellite module according to one embodiment of the invention.

10 FIG. 12 illustrates a cable modem module according to one embodiment of the invention.

FIG. 13 illustrates copyright tags implemented in one embodiment of the invention.



## DETAILED DESCRIPTION

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the invention may be practiced without some of these specific details. In other instances, well-known structures and devices are shown in block diagram form to avoid obscuring the underlying principles of the invention.

### EMBODIMENTS OF A CENTRALIZED MULTIMEDIA AND COMPUTING SYSTEM

#### *System Overview*

As illustrated in **Figure 1**, in one embodiment of the invention, a digital media server 110 equipped with a processor and a mass storage device acts as a central repository for decoding, storing and distributing multimedia content and data. More particularly, the digital media server 100 coordinates multimedia content from Internet communication channels 120 (e.g., DSL, cable Internet), broadcast communication channels 130 (e.g., digital/analog cable, satellite), and/or Public Switched Telephone Network ("PSTN") communication channels 170 (i.e., standard telephone) to provide a stable, real-time home media network 140 for a plurality of network devices 150-151, 160-166.



### *One Embodiment of a Home Media Server Architecture*

As illustrated in **Figure 2a**, one embodiment of a home media server 110 computing architecture includes a central processing unit 200 capable of processing data and multimedia content stored in main memory 201 and a mass storage device 230 for storing data and multimedia content. In one embodiment, the central processing unit 200 is a Pentium®-class processor such as a Pentium III® operating at a 1 GHz or faster clock frequency. It should be noted, however, that the underlying principles of the invention are not limited to any particular processor speed or processor type. The main memory 201 may be a random access memory or any other dynamic storage medium (e.g., SDRAM, DDRAM, RD-RAM, . . . etc). The mass storage device 230 of one embodiment is capable of storing hundreds, or even thousands of hours of multimedia content (e.g., movies, digital audio, . . . etc) as well as other types of digital data (e.g., computer programs, word processing documents, . . . etc). Devices transmit and receive data to/from the mass storage device 230 over a high speed interface such as an enhanced IDE interface with Ultra DMA capabilities or a Small Computer System Interface ("SCSI"). However, various other interfaces may be employed while still complying with the underlying principles of the invention.

An application-specific integrated circuit ("ASIC") 210 coordinates communication between the various system components and offloads certain designated processing tasks from the CPU. The ASIC may be custom built based



on the requirements of the home media server 110 or may be built using gate arrays, standard cells or programmable logic devices.

Communication modules 240-245 electrically coupled to the home media server 110 via a system bus 220, allow the home media server 110 to  
5 communicate over different local and remote communication channels. In one embodiment, the system bus 220 is a peripheral component interconnect ("PCI") bus, although various other bus types may be configured within the home media server 110 (e.g., ISA, EISA, Micro Channel, VL-bus . . . etc).

In the particular embodiment illustrated in **Figure 2a**, the communication  
10 modules 240-245 electrically coupled to the system bus 220 include an RF network module 240 for communicating over the home media network 140 (i.e., via a wireless RF channel), a cable TV module 241 for receiving broadcast cable channels, a cable modem module 242 for providing Internet access via a cable system (i.e., using the TCP/IP protocol), a satellite TV module 243 for receiving  
15 satellite broadcasts, and a DSL module 244 for DSL Internet access. Moreover, a virtually unlimited number of new modules may be added as necessary to support new or existing communication channels/protocols (as indicated by module 245).

Other components within the home media server 110 architecture include  
20 an MPEG-2 decode module 202 (and/or other decode modules such as AC3,



09653964-090100  
MPEG-1, . . . etc); an audio module 203 comprised of a digital-to-analog  
converter, a Sony-Philips Digital Interconnect Format ("SP-DIF") interface and a  
standard telephony interface for providing digital and analog audio and  
standard telephone service to external audio/telephony devices; an Ethernet  
5 port provided directly the system ASIC 210 (as indicated by the "100 Base-T  
Ethernet" designation); a Firewire (IEEE 1394) port 204; a Universal Serial Bus  
("USB") port 205; and an infrared port 206. Various other communication  
interfaces may be configured in the system, either directly on the primary home  
media server architecture 110 (e.g., on the media server 110 "motherboard"), or  
10 as an add-on module 240-245. Moreover, the communication modules (e.g., 202-  
206), the CPU 200 and/or the memory 201 may be incorporated within the  
system ASIC 210, rather than as separate modules as illustrated in **Figure 2a**.

Embodiments of the home media server 110 may also be equipped with a  
DVD drive, CD player, CD Read-Write drive, recordable DVD drive (as  
15 described in greater detail below), and/or any other type of portable storage  
medium 235. In one embodiment, these devices may communicate with the  
home media server 110 via an AT Attachment Packet Interface ("ATAPI"),  
although the type of interface used is not pertinent to the underlying principles  
of the invention.

20 **Figure 2b** illustrates a software architecture employed in one embodiment  
of the home media server 110. Different hardware architectures 280 may be used



to support the software, including the hardware architecture illustrated in **Figure 2a**. A multitasking, multithreaded operating system ("OS") 270 (e.g., Linux, UNIX, Windows NT®) with real time streaming support is executed on the hardware 280. In one embodiment, certain proprietary customizations 292 are  
5 programmed in the media server OS 270 including, for example, real time services for streaming audio and video (real time OSs typically do not include these features).

A media toolkit 260 executed within the home media server 110 provides an application programming interface ("API") for the different media server 110  
10 applications described herein as well as a set of media server 110 utilities. In one embodiment, a minimum quality of service ("QoS") is defined within the media toolkit 260. The media toolkit 110 may be comprised of several functional layers including a media stream abstraction layer; a media stream resource management layer; a security/conditional access layer; and a transport/storage  
15 abstraction layer.

In one embodiment, the home media server 110 is configured with support for the realtime transport protocol ("RTP") and the realtime streaming protocol ("RTSP") (see, e.g., RTP/RTSP module 251). Briefly, RTP is an IP  
20 packet typically resides on top of a user datagram protocol ("UDP") and includes timestamping and synchronization information in its header for proper



reassembly at the receiving end. RTSP is a well known protocol for streaming multimedia content over a network. It should be noted, however, that various other streaming protocols may be implemented while still complying with the underlying principles of the invention (e.g., Quicktime®, Windows Media, . . .  
5 etc).

RTP and RTSP were designed primarily for PC to PC communication over non-realtime networks. Accordingly, because one embodiment of the home media server 110 operates over a realtime home media network 140 and communicates to devices other than PCs (e.g., media nodes 150, 151), certain  
10 optimizations 290 may be programmed within the RTP/RTSP component 251. These include, for example, support for multiple data streams between the home media server 110 and the various multimedia devices 150, 151; 160-166 (e.g., one or more video streams and several audio streams)

Apache HTTP server support 250 is also included in one embodiment of  
15 the home media server 110. Apache is an open-source HTTP server software product which may be executed on various modern desktop and server operating systems. Once again, certain media server customizations 290 may be included within the Apache component 250, further refining HTTP support for the home media network 140 environment.



In one embodiment, a plurality of device servers 252 are executed on the home media server 110. These devices servers provide application support for each of the media nodes 150-151 and other devices 160-166 communicating with the home media server 110 over the home media network 140. For example, in response to a "tune" command sent from a media node 150, a tuning device server will cause the home media server to tune to a broadcast channel specified by the tune command. The tuning server may also include conditional access functionality (i.e., only allowing tuning to occur for channels to which the user has access rights).

Although described above as a "software" architecture, it should be noted that various elements illustrated in **Figure 2b** may also be implemented in firmware and/or hardware while still complying the underlying principles of the invention.

Referring again to **Figure 1**, numerous digital and analog devices may be configured to communicate with the home media server 110 over the home media network 140. By way of example, and not limitation, these include personal computers 160, cameras or digital camcorders 161, printers 162, notebook computers 163, automotive audio/video systems 164, cell phones or personal digital assistants 165, standard telephones 165 (including fax machines), home security systems (not shown); and/or home climate control systems (not shown).







to communicate over terrestrial transports, depending on the requirements of the particular configuration.

### *One Embodiment of a Multimedia Node Architecture*

Distributed multimedia nodes 150 and 151 illustrated in **Figure 1** provide  
5 an interface to the home media network 140 for audio systems 170 (e.g., audio amplifiers and speakers) and/or video systems 171 (e.g., standard television sets, wide screen television sets, high definition television ("HDTV") sets, or any other device capable of displaying video).

As illustrated in **Figure 6**, one particular embodiment of a multimedia  
10 node architecture (see, e.g., node 150 in **Figure 1**), is comprised of a network interface 605 coupled to the multimedia node bus 610 (e.g., a PCI bus); a system ASIC 620, including MPEG-2 decode/graphics logic 630 (or other multimedia decode logic); a central processing unit 640 and memory 650; an audio processing unit 660; and/or an infrared port 670.

15 The local central processing unit 640 and memory 650 execute programs and process data locally (i.e., at the multimedia nodes 150, 151). The network interface 605, which may be an RF interface or a terrestrial interface (e.g., Ethernet), receives/transmits multimedia content and control data from/to the home media server 110 over the home media network 140. The system ASIC 620  
20 decodes and processes incoming multimedia content transmitted from the home



media server 110 via MPEG-2 decode/graphics logic 630 (or other multimedia compression standard) to produce one or more video outputs 680 (e.g., an NTSC output, an HDTV output, . . . etc). In one embodiment, a separate audio processing unit 660 produces both digital and analog audio outputs, 681 and 682, respectively. Moreover, one embodiment also includes a local mass storage device (not shown) for storing certain multimedia content and/or data (e.g., frequently-requested content/data).

In one embodiment, the local infrared interface 670 receives control commands from a remote control unit (e.g., unit 532 in **Figure 5**) operated by a user. As described below with reference to **Figure 5**, control data/commands received through the infrared interface 670 may subsequently be transmitted to the home media server 110 for processing. For example, in one embodiment, if a user selects a command to change to a live broadcast channel (e.g., the evening news), the command is transmitted from multimedia node 151 to a home media server 110 tuning application, which forwards the command to a video module (e.g., CATV module 241, satellite TV module 243). The tuner in the video module (see, e.g., tuner 910 in **Figure 9**) then tunes to the requested frequency and the new video signal is streamed from the home media server 110 to the multimedia node 151. Alternatively, or in addition, if the requested content was previously stored on the home media server 110 (e.g., on mass storage device 230), then no broadcast tuning is necessary – the content is simply read from the storage device 230 and transmitted to the multimedia node 150. Accordingly, as



described in greater detail below, the amount of audio/video content which must be broadcast to the home media server 110 (i.e., over dedicated broadcast channels) is significantly reduced.

One embodiment of a multimedia node 150 software architecture is illustrated in **Figure 6b**. Various hardware architectures 690 may be used to support the software architecture, including the architecture illustrated in **Figure 6a**. An operating system 691 executed on hardware 690 (e.g., Windows '98, Linux, . . . etc) includes client customizations for optimizing communication over the home media network 140 (e.g., providing low level support for real time streaming of audio and video).

A standard set of user interface components 694 included in one embodiment may be employed (e.g., by application developers) to generate unique interactive interfaces at each of the media nodes 150, 151. For example, a user-navigable tuning index may be included which lists available content by dates/times and allows users to graphically select a particular broadcast channel and/or stored content from the mass storage device 230.

In addition, support for the hypertext markup language ("HTML") and/or the extensible markup language ("XML") are included in one multimedia node 150 embodiment, allowing users to download, view and modify various types of Internet content (e.g., Web pages).



Applications executed on multimedia nodes 150, 151 may include client-specific applications 697 and/or home media server 110 control applications 696. Two examples of media server control application 696 will now be described with reference to **Figures 6c-6d**. It should be noted, however, that these

5 examples are for the purpose of illustration only and should not be read to limit the scope of the invention.

**Figure 6c** illustrates an embodiment for tuning to a particular broadcast channel (e.g., cable, satellite broadcast). A user initially selects a particular channel (e.g., via a remote control device) to be viewed at the local multimedia

10 node 151. The command is received by the local TV tuning application 601 executed on the multimedia node 151, which sends a tuning request to the home media server 110 over the home media network 140. A tuner server module 602 executed on the home media server 110 receives the request and forwards the request to the tuner driver 271 (e.g., through the media toolkit 260). In response

15 to the command, the tuner driver 271 directs the tuner hardware (see, e.g., tuner 910 in **Figure 9** described below) to tune to the specified channel. The tuner driver also communicates with the conditional access subsystem (see, e.g., module 930 in **Figure 9**) to determine whether the user has the right to view the particular channel (e.g., the channel may be a subscription-based channel such as

20 HBO).



09653964-090100

If the user has access rights, then the tuner server module 252 creates video stream for the specified broadcast channel and feeds the stream to the multimedia node 151. In one embodiment, the tuner server module 602 creates the stream using the RTP/RTSP protocol (i.e., by communicating with the RTP/RTSP module 251). The media node receives the stream through the local TV tuning application 601 and decodes the stream using a codec embedded within the media toolkit 260 (various additional encoding features of the system are set forth below). Once decoded, the video image is generated on the video display.

**Figure 6d** illustrates an embodiment for employing a music jukebox at a multimedia node 150. A user initially selects a particular music play list (e.g., via a remote control device) to be played at the multimedia node 150. The request is received by a music jukebox application 601 executed on the multimedia node 150, which forwards the request to the home media server 110. A jukebox server module 604 executed on the home media server 110 receives the request and forwards the request to the media server file system 606 (through the media toolkit 260), which retrieves the music files from the mass storage device 230. The jukebox server module 604 then creates the audio stream for the specified files and feeds the stream to the multimedia node 150. In one embodiment, the tuner server module 252 uses the RTP/RTSP protocol to create the stream (e.g., through communication with the RTP/RTSP module 251). The multimedia node 150 receives the stream through its jukebox application 601 and decodes the



stream using a codec embedded within the media toolkit 260. Once decoded, the music tracks are reproduced on a set of speakers.

### *Network Operations Center*

In one embodiment, a network operation center ("NOC") 180 illustrated in Figure 1 provides data and multimedia services for the home media server 110. The NOC may be comprised of one or more servers communicating with the home media server 110 over the Internet 120 (or other network). In one embodiment, the NOC performs one or more of the following functions:

Remote Monitoring and Maintenance. The NOC 180 monitors the home media server to ensure that it is operating within normal parameters. In one embodiment, the home media server 110 periodically transmits a status update to the NOC 180, indicating whether any particular services are required and/or whether any problems have arisen. If the home media server 110 fails to transmit a status update after a predetermined period of time, the NOC 180 may take steps to determine the cause of the problem and/or take steps to contact the user. For example, diagnostic tests may be performed to evaluate the network connection between the home media server 110 and the NOC 180. If the diagnostic tests do not provide an answer, then the user may be contacted via telephone to determine the next course of action. In one embodiment the NOC 180 is staffed by engineers or other technical assistance personnel 24-hours a day.



09553964 "090100

In one embodiment, the user's home security system and/or fire system communicates with the home media server 110 over the home media network 140. Accordingly, the home media server 110 may be programmed to relay home security and/or fire system data to the NOC 180 on a periodic basis during certain periods of time (e.g., every minute). If a security problem or fire trouble indication is encountered during this period of time (e.g., a door/window is opened without the proper security access code), the NOC 180 may notify a local law enforcement agency and/or the local fire department.

Automatic Downloading and Upgrades. In one embodiment, the NOC 180 provides automated software downloading and upgrades to the home media server 110. For example, when a new software interface/program (e.g., a new graphical user interface) is developed for the home media server 110 it may be automatically downloaded from the NOC 180 and installed. Whether the NOC 180 should upgrade software on the home media server 110 automatically may be determined by each individual user. Certain users may opt to manually upgrade all of their software while other users may specify a particular subset of software to be automatically upgraded. For example, a user may specify automatic upgrades for graphical user interface software and manual upgrades for email clients and word processors.

In addition, the NOC 180 may store up-to-date drivers for various home media network devices 160-166. In one embodiment, when a user purchases a







(e.g., those which perform inefficient bus transactions which tie up the system bus 220) will not be certified by the NOC 180 and will not be permitted to be installed in the home media server 110.

In addition, in one embodiment the communication modules 240-245 are  
5 manufactured and certified by third party content providers (e.g., satellite broadcast operators). In this embodiment, the content providers may configure the modules 240-245 to work with their own proprietary communication protocols, encryption techniques, and/or application programs. For example, DirecTV™ may develop a proprietary interface for its users so that when a user  
10 selects his DirecTV feed he will be presented with a unique user interface and/or channel programming environment. Accordingly, while the present invention provides a standard media transport interface for a variety of different communication channels, service providers can still distinguish their services based on the proprietary applications/ transports which they develop.

15 Logging/Data Warehousing. In one embodiment, the NOC 180 may perform logging and data warehousing for the home media server 110. More specifically, the NOC 180 may maintain a log of network transactions for each home media server 110 and subsequently evaluate the log for a variety of reasons (e.g., to troubleshoot system problems, to determine a user's preferences and  
20 tailor services and/or advertising to that user, . . . etc). For example, by monitoring usage patterns, the NOC 180 may determine that every time a certain



Java applet is downloaded, the home media server 110 crashes. As such, the NOC 180 may take steps to ensure that the applet in question is no longer downloaded by the home media server 110 (e.g., by notifying the user or automatically blocking the applet). The NOC 180 could then notify the technical support staff to determine the problem with the applet.

Similarly, the usage log may be evaluated to determine the preferences of a user and to provide specialized services to that user based on those preferences. For example, based on the Web sites the user visits and/or the channels that the user watches, the NOC 180 may determine that the user is interested in baseball. As such, the NOC 180 may automatically provide baseball-related content to the user such as, for example, broadcast schedules for upcoming games, a subscription offer to a sports magazine, advertisements, and various other baseball-related content. Similarly, the NOC 180 may determine that the user watches certain television shows on a regular basis, and may automatically download/record those shows on the home media server 110 (e.g., via TCP/IP), so that they will be readily available for the user (e.g., during non-broadcast periods of time).

Archiving. In one embodiment, users may backup multimedia content and other types of data at the NOC 180. For example, a user may take a series of pictures with a digital camera and transmit the originals to the NOC 180 for developing. In one embodiment, the NOC will transmit the pictures to a



developer on behalf of the user and will store a backup copy of each of the originals (the NOC 180 will be backed up regularly to prevent loss of the originals).

In one embodiment, the NOC 180 will monitor all multimedia content purchased by the user over the Internet. For example, when the user downloads a new compact disk ("CD") from a music download site, the NOC 180 will record the transaction in the user's profile. As such, the user does not need to store all of his/her multimedia content locally on the home media server 110. Rather, because the NOC 180 keeps track of all the content to which the user has access rights, the user can offload storage to the NOC 180 and re-download the content when necessary (e.g., following a hard drive failure on the home media server 110).

Registration/configuration. In one embodiment, users may be required to register with the NOC 180 upon purchasing a home media server 110 and related network devices 150-151, 160-166. The NOC 180 may prompt each user to respond to a series of question directed to the user's preferences, the type/level of NOC 180 services desired by the user, the authorization level of each user in the home media server 110 household (e.g., children may be provided with limited limited functionality), and any other user-related data which may aid the NOC 180 in providing user services. In one embodiment, the NOC 180 will automatically detect the home media server 110 configuration and store this data















telephone 304, XGA/HDTV 306, and/or other standard audio/video ports (e.g., AV output ports 307 and 308) may be installed directly in the primary home media server, rather than as an expansion card.

As illustrated in **Figure 4**, one embodiment of the system includes a DVD  
5 player 420 (and/or a CD player, CD-ReWritable drive, recordable DVD drive or other type of portable digital media player/recorder). The DVD player 420 is capable of playing a DVD directly and/or transferring multimedia content from the DVD to the mass storage device 230. In one embodiment, as multimedia content is transferred to the storage device 230, either from the DVD player 420  
10 or over the Internet 120, an indexing module executed on the home media server 110 indexes the multimedia content in a content database (not shown).

Various DVD/CD identification techniques may be used to identify the particular DVD/CD inserted and copied to the storage device 230. For example, a checksum may be calculated for a known unique portion of the DVD/CD and  
15 compared with a CD/DVD checksum database (e.g., maintained at the NOC 180 or other server). Similarly, the serial number may be read from the DVD/CD and compared with a database of DVD/CD serial numbers. Additional DVD/CD identification techniques which may be utilized in accordance with the principles of the invention are disclosed in co-pending applications entitled  
20 SYSTEM AND METHOD FOR SCALING A VIDEO SIGNAL, Serial No. 09/632,458, filed August 4, 2000; and COMPACT DISK AND DIGITAL VIDEO



DISK STORAGE AND PLAYBACK SYSTEM, Serial No. \_\_\_\_\_, Filed \_\_\_\_\_,

each of which are assigned to the assignee of the present application and which are incorporated herein by reference.

09653964-090100  
In one embodiment of the system, the storage device 230 (e.g., a hard  
5 drive) is preferably large enough to store hundreds of hours of video and/or  
audio content, as well as a variety of other digital information such as telephone  
voice messages, computer programs/data . . . etc. The current recommended  
size for the storage device 230 is at least 80 gigabytes, however the particular size  
of the storage device is not pertinent to the underlying principles of the  
10 invention.

One or more RF transmitters 430 are also provided in one embodiment of  
the home media server 110. The transmitter 430 (as well as the LAN 390, if one is  
installed) allows the home media server 110 to simultaneously transmit  
multimedia content and other types of data to the various media devices 150-151,  
15 160-166 over the home media network 140 (e.g., at least one MPEG-2 video  
stream and several audio streams).

In one embodiment, the wireless transmission system is capable of  
handling isochronous multimedia traffic reliably (i.e., without jitter) in a wide  
range of residential settings. For example, the system must be capable of  
20 working in the presence of common residential RF interference such as



microwave ovens and cell phones. In one embodiment, these requirements are met through the proper choice of modulation and coding. More specifically, one embodiment employs a modified version of IEEE 802.11b adapted to operate in a real time environment (e.g., using Reed-Solomon forward error-correction and antenna diversity with circular polarization).

**Figure 5** illustrates a home media server 110 communicating simultaneously with a video node 520 and an audio node 522. Certain multimedia nodes, such as node 522, include an LCD 524 (or other type of display) for displaying information about the multimedia content stored on home media server 110 (e.g., CD and movie titles, CD tracks . . . etc). In one embodiment, the audio node 522 may be electrically coupled to an amplifier for amplifying the transmitted audio signal into a pair of speakers. As described above, in one embodiment, the individual multimedia nodes also include local storage devices (not shown) for locally caching recently used multimedia content and data.

Data/commands sent from remote control devices 530, 532 are transmitted through the nodes 520, 522 to the home/media server 110 as indicated. In one embodiment, the remote control devices include an LCD (not shown) or other type of display for displaying information about the multimedia content stored on home media server 110 (i.e., instead of, or in addition to, the multimedia node 522 display 524).







feature are set forth in the co-pending applications incorporated by reference above.

In an embodiment which includes a CD-ReWritable ("CD-RW") drive, users can produce custom CDs using the audio content stored on the mass storage device 230 or downloaded from the Internet. The CD-RW drive may utilize serial copy management techniques to produce CDs which cannot themselves be copied, thereby protecting the copyrights to the underlying works. Moreover, in one embodiment, the system will determine whether the content owner or content creator allows copying of the multimedia content. For example, certain content creators/owners may allow a copy to be stored on the home media server mass storage device 230, but may not allow copying to a portable disk (e.g., a CD-RW disk). In one embodiment, content stored on the mass storage device 230 may be labeled as non-copyable by setting one or more "copy" bits to a particular value (e.g., in a bit field associated with the content).

In one embodiment of the system, a portable music/video player node may be configured to retrieve multimedia content directly from the home media server 110 or via an adapter module. Portable MP3 players such as the Rio™ from Diamond Multimedia™, for example, may be used to store and play back digital audio content transmitted from the home media server in a flash memory module. In one particular embodiment, the CD-RW drive 420 is capable of accepting the 1/3 inch "mini CD" format. Accordingly, users may produce







In one embodiment, a user may publish a home Web page containing up-to-date information on each home appliance or other network device.

Accordingly, users of this embodiment are able to monitor and control home appliances and systems from anywhere in the world. In one embodiment this  
5 includes the ability to select broadcast listings and direct the home media server 110 to make recordings (e.g., based on date/time or broadcast ID code). In addition, in one embodiment, users may connect remotely to the home media server to review email and/or voicemail listings (which may be displayed to the user in the form of a single, generic "message" box). Voicemail messages may be  
10 streamed to the remote user's location over the Internet or other network.

### *Telephony Embodiments*

As illustrated in **Figure 7a**, in one embodiment, home telephone devices 166 may also be configured to run through the home media server 110. In this embodiment, incoming faxes and voicemail are stored on the home media  
15 storage device 230 and may be accessed from any room in the house (e.g. from telephone devices 166, personal computers 160, PDAs 165, and/or video systems 151/171). In addition, phone number and address information may be stored in a contact database 740 on the home media server 110 and accessed through the various telephone devices 166 (or other home media devices). Offloading user  
20 contact data from the telephone devices 166 in this manner allows telephone devices 166 to be manufactured with less memory and less processing power, further decreasing costs to the end user.



001000" 1965960

As illustrated in **Figure 7a**, in one embodiment, the home media server 110 includes a telephone connection module 730 which coordinates between standard telephony calls placed/received over the public switched telephone network ("PSTN") 170 and calls placed over the Internet 120 using IP telephony protocols. The telephone connection module 730 will automatically route incoming calls from both sources to the same set of home telephone devices 166 (or other home media devices such as the user's personal computer 160).

Users may specify whether a particular outgoing call should be placed over the Internet 120 (e.g., to an IP telephony device 710) or over the PSTN 170 (e.g., to a standard telephone device 720). In one embodiment, the telephone connection module 730 analyzes each outgoing telephone connection request to determine whether the call should be routed through the Internet 120 or through the PSTN 170. The telephone connection module 370 may factor in various types of connection data to make telephone connection determinations. For example, a user may specify certain contacts within the contact database 740 for which IP telephone connections should be used and certain contacts for which standard telephone connections should be used. In one embodiment, the telephone connection module 730 will select a particular connection based on whether it is the least expensive option for the user (e.g., for contacts with both IP and standard telephone capabilities). Another variable which may be factored into the selection process is the connection throughput available to the user over the Internet. More specifically, the telephone connection module 730 may initially



test the connection throughput (including the availability of a reliable connection) over the Internet 120 and place an IP telephony call only if some minimum level of throughput/reliability is available. Any of the foregoing variables, alone or in combination, may be evaluated by the telephony connection module 730 to select and appropriate telephone connection.

One embodiment of a protocol architecture for supporting IP telephony and related communication functions on the home media server 110 is illustrated in **Figure 2b**. Various telecommunication standards are supported by this embodiment, including the H.248 media gateway control standard ("MEGACO") standard; the ITU-T H.323 and session initiation protocol ("SIP") standards for multimedia videoconferencing on packet-switched networks; the Realtime Control Protocol ("RTCP") standard – a companion protocol to the realtime transport protocol ("RTP") (described above) used to maintain a minimum QoS; and the ITU T.120 standard for realtime data conferencing (sharing data among multiple users).

In addition, various audio and video codecs are supported by the illustrated embodiment, including G.711, G.723, and G.729 (for audio); and H.261 and H.261 (for video). As illustrated, each of these codecs may be executed above RTP, an IP protocol that supports realtime transmission of voice and video. Each of the foregoing IP communication protocols may be utilized by



media server 110 application programs through the programming interfaces of the media toolkit 260.

It should be noted that, although the embodiment illustrated in **Figure 7b** includes a specific set of communication protocols, various other communication protocols may be implemented within the home media server 110 while still complying with the underlying principles of the invention. For example, in one embodiment, new protocol stacks (both proprietary and industry-standard) may be automatically transmitted from the NOC 180 and installed on the home media server 110 as they become available.

**Figure 7c** illustrates a signal diagram representing the set up and termination of a telephony connection according to one embodiment of the home media server 110. At 750, the home media server transmits a call connection "invitation" on behalf of User 1 to User 2. Once User 2 accepts the call, a "success" message is transmitted back to the home media server 110 at 751. In response, the home media server 110 acknowledges receipt of the "success" message at 752 and allocates a media stream 760 to support bi-direction audio communication between User 1 and User 2. To tear down the media stream 760, one of the users must hang up the phone, resulting in a "bye" message 753, 754 followed by a termination acknowledgement ("success") from both sides 755, 756.



● ●

10

20



amount of inefficiently used broadcast network bandwidth (pre-recorded content currently represents the vast majority of all broadcast content).

As indicated in **Figure 8b**, this embodiment of the home media server 100 will provide a seamless mechanism for transitioning from standard digital broadcast channels (e.g., MPEG-2 channels) and analog broadcast channels to packet switched isochronous channels (for live broadcasts) and asynchronous channels (for pre-recorded broadcasts). Initially, the breakdown between broadcast and packet switched channels (e.g., TCP/IP) will be similar to that illustrated in column 804, with analog broadcast 803 taking up approximately half of the available bandwidth, with the other half split between digital broadcast 802 and packet switched channels 800. As content providers begin to switch over to a packet-switched transmission scheme, this breakdown will change as indicated at bandwidth allocation 805, with packet-switched channels taking up approximately half of the available bandwidth and the remainder split between analog broadcast 812 and digital broadcast 811.

Finally, when standard analog and digital broadcast channels have been phased out completely, all content will be delivered over packet switched channels as indicated in bandwidth allocation 806. Many packet switched protocols support both asynchronous and isochronous data transmissions. Accordingly, several isochronous channels may be provided to support live, real time events (e.g., sports events, the evening news, . . . etc) and the remainder of



the bandwidth may be allocated to pre-recorded events (e.g., sitcoms, game shown, talk shows, . . . etc). These pre-recorded events/shown may be asynchronously downloaded to the home media server 110 at any time of the day or evening (e.g., during periods of low network activity), resulting in a much more efficient allocation of available transmission bandwidth.

Because embodiments of the home media server 110 described above are capable of receiving, storing and coordinating content transmitted from both packet switched channels (e.g., TCP/IP) and standard broadcast channels, the transition illustrated in **Figure 8b** may be accomplished seamlessly, while at the same time improving the overall quality of service to the end user.

In one embodiment, several concurrent, real-time multimedia streams are supported by the home media server 110 through buffering and/or disk storage techniques as illustrated in **Figure 8c**. More specifically, incoming multimedia content 860-862 from several different channels (e.g., standard broadcast channels 860, 861 and packet switched channels 862, 863) may be buffered in a set of input buffers 870-873 and output buffers 890-893 on the home media server 110. The input buffers and output buffers 870-873 and 890-893, respectively, may be portions of memory allocated within the main memory 201 (see **Figure 2**). Alternatively, or in addition, the input/output buffers may be configured on the communication modules 240-245, within the system ASIC 210, and/or as separate modules on the home media server 110 motherboard.



In one embodiment, the mass storage device 230 reads the multimedia data from each of the input buffers 870-873 and writes the data to a set of multimedia tracks 880-883. The multimedia data is subsequently read from each of the multimedia tracks 880-883 to a set of output buffers 890-893, from which it is transmitted to one or more of the destination multimedia devices 150, 151, 163. Buffering data streams on the home media server 110 in this manner provides significant cost efficiencies for the entire system. Specifically, because the multimedia data is buffered at a single distribution point within the home media network 140 (i.e., the home media server 110), no buffering is required at each of the individual multimedia devices 150, 151 and 160-166, thereby significantly reducing the cost and complexity of these devices.

The mass storage device 230 of this embodiment has enough bandwidth in its read/write operations to support several multimedia streams at once.

Although the seek time of the mass storage device 230 (i.e., the time required to  
15 jump from one track to another) may be relatively low (i.e., relative to its  
read/write bandwidth), buffering of the multimedia data in input and output  
buffers as described ensures that the various streams will be provided to their  
respective multimedia devices 150, 151 and 160-166 without interruption.

In one embodiment, each of the multimedia streams 860-863 operate  
20 independently of one another. For example, if playback of a particular  
multimedia stream is paused, e.g., from multimedia device 150, the home media



server 110 will interrupt transmission of multimedia content from the output buffer 893 associated with that device 150, and will begin storing subsequent, incoming multimedia content on the mass storage device 230 (e.g., within the media track 883). However, this will not affect playback at any of the other  
5 multimedia devices on the network 140. When playback is resumed, the content will be streamed from the output buffer 893 (and media track 883) from the same point at which it was paused (thereby providing real time, time-shifting functionality for live, real-time broadcasts).

In one embodiment, an indexing module (not shown) will generate a  
10 content index for users of the home media server 110 which will provide users with a comprehensive, seamless listing of multimedia content from the Internet (e.g., streaming media content), broadcast channels (including live and pre-recorded broadcast channels), asynchronous/isochronous multimedia channels, and/or various other media sources/channels. Accordingly, this embodiment  
15 will provide users with the ability to navigate through and select content from a virtually unlimited number of different multimedia sources and channels having any knowledge of the underlying protocols and communication infrastructure supporting the sources/channels.

### *Intelligent Buffering and Bandwidth Allocation*

20 Virtually all communication channels are bandwidth-limited in some manner, due to the physical limitations of the underlying transmission medium



and/or the signaling limitations of the channel (e.g., the channel's allocated frequency spectrum). For example, a 100 Base-T Ethernet network is capable of providing a total data throughput of 100 Mbps, which is shared by all nodes (e.g., computers) on the network. Similarly, multimedia devices 150, 151; 160-166 communicating on the home media network 140 described above all share some maximum network signaling rate (e.g., if a standard IEEE 802.11b network is employed the signaling rate is 11 Mbps).

Because bandwidth is shared on these systems, overall network performance may degrade as a result of nodes performing concurrent, high-bandwidth network transactions. This can be particularly problematic on networks such as the home media network 140 which support real-time multimedia services. More specifically, high quality audio and video signals transmitted from the home media server 110 to multimedia nodes 150, 151, require some minimum level of network bandwidth to be rendered properly (i.e., without distortion or interruption). Accordingly, one embodiment of the invention includes intelligent buffering and bandwidth allocation techniques to ensure smooth playback of the multimedia signal at each of the multimedia nodes 150, 151.

**Figure 9a** illustrates a histogram of normalized bitrate data for a particular multimedia stream (e.g., a DVD) over a period of 120 seconds. Curve 902 shows the bitrate averaged at one second intervals whereas curve 904 shows the bitrate



averaged at 10 second intervals. The average bitrate over the entire 120 second interval is represented by curve 906 (approximately 4.7 Mbps). Accordingly, based on the histogram data, the effective bitrate required to properly render the video stream at multimedia node 150 fluctuates significantly – from a maximum throughput of 7.143 Mbps to a minimum throughput of 1.657 Mbps.

One embodiment of the home media server 110, illustrated in **Figure 9b**, uses this type of bitrate data to allocate bandwidth and buffering levels for multimedia playback. Accordingly, when a user selects audio or video content (e.g., a DVD) to be transmitted to a multimedia node (e.g., video node 151), the home media server 110 initially retrieves a bitrate template 930 (e.g., a histogram of bitrate data) associated with the requested content from a bitrate database 935. The database 935 may be maintained locally on the home media server 110 and/or, as illustrated, may be maintained on a remote database server 940 (e.g., maintained at the NOC 180). In either case, the database 935 may be continually updated as new multimedia content becomes available. Once the bitrate template 930 is initially downloaded from the remote server 940, a copy may be stored locally on the home media server 110 for future reference. In one particular embodiment, the bitrate template 930 may be transmitted along with the underlying multimedia signal (e.g., embedded within the MPEG-2 stream read from a DVD or broadcast over a cable channel), rather than maintained in a separate database 935.



If the bitrate template 930 is maintained in a database 935, various types of identification data 925 may be used to identify the correct template for the multimedia content being played including, but not limited to, those set forth in co-pending application entitled SYSTEM AND METHOD FOR SCALING A VIDEO SIGNAL, Serial No. 09/632,458 (incorporated by reference above). For example, a checksum may be calculated for a known unique portion of the multimedia content and compared with checksums stored in the database 935. Similarly, if the content is stored on a CD or DVD, the CD/DVD serial number (or other embedded identification code) may be used to perform a database 935 query. Various other identification techniques may be used to identify the multimedia content while still complying with the underlying principles of the invention. Once the correct bitrate template 930 is identified, it is transmitted from the remote server 940 to the home media server 110. Alternatively, if the data is stored locally on the home media server 110, it is retrieved directly from the home media server's storage device 230.

In one embodiment, an allocation module 950 running on the home media server 110 analyzes the bitrate template 930 to establish an efficient bandwidth allocation and/or buffering policy for transmitting the multimedia stream(s). The allocation module 950 acts as a data "throttle," increasing or decreasing the data throughput from the home media server 110 to the multimedia nodes 150-151 as necessary to meet the bitrate requirements of each multimedia stream (e.g., through control of the home media server output buffers 910-912 and/or



RF transceiver 915). The goals of one embodiment of the system are (1) to ensure that the underlying multimedia content is reproduced at the multimedia node 151 without interruption/jitter; (2) to minimize the memory requirements at the multimedia node 151; (3) to minimize the playback delay experienced by the end user; and/or (4) to minimize the bandwidth required to accurately reproduce the multimedia content at the node 151. Any of these goals, alone or in combination, may be factored into the allocation module's 150's bandwidth/buffering allocation policy.

In one embodiment, the allocation module 950 analyzes the bitrate template 930 to ensure that the amount of multimedia content in each multimedia node buffer – e.g., buffer 920 of multimedia node 151 – is sufficient to handle upcoming spikes. For example, given the bitrate template data set forth in **Figure 9c**, the multimedia node buffer 920 must have sufficient multimedia data (i.e., an adequate number of bits) to handle the bitrate spike between 3 seconds and 4 seconds (i.e., 6.2 Mbps). As such, by analyzing the bitrate template 930 as a whole, the allocation module 950 may increase the allocated data throughput between 1 second and 3 seconds to sufficiently fill the buffer 920 by the time the bitrate spike arrives (i.e., at 3 seconds). Thus, the number of bits consumed during the spike (6.2 Meg) must be less than or equal to the number of bits in the buffer at start of spike period (3 seconds) minus the bits added to buffer during spike period (i.e., the per-second bitrate). Otherwise, playback of







foregoing bandwidth/buffer allocation example was for the purpose of illustration only and should not be read to limit the scope of the invention.

In one embodiment, the when a new playback stream is requested at a multimedia node 151, the allocation module 950 will initially allocate all system bandwidth available at that time to the stream. It will subsequently decrease the bandwidth (i.e., the "throttle") only when other multimedia nodes require additional bandwidth and/or when the buffer at the multimedia node 151 fills up. Accordingly, one goal of this embodiment is to keep the buffer at the multimedia node 151 filled to its limit at all times (e.g., so that it will be ready for upcoming spikes).

Playback of the multimedia data from the multimedia node buffer 920 may start at different times, depending on the histogram data associated with the content. For example, the bitrate for certain high definition television broadcasts or DVDs such as the one illustrated in **Figure 9e** (which shows bitrate data for the movie "South Park") may start off at a relatively high value (i.e., approximately 8.6 Mbps). As such, it may be necessary to accumulate a certain amount of multimedia data in the multimedia node buffer 920 before initiating playback. The table 970 illustrated in **Figure 9e** shows the amount of data that must be buffered before playback (column 972), given a particular multimedia stream bitrate (column 971). The table 970 also indicates the amount of time which a user must wait before playback begins (column 973). As indicated in the



bottom row of the table 970, at a bitrate of 9Mbps, no buffering of the multimedia signal is required. In one embodiment, playback is initiated by the allocation module 950 (as indicated by the control signal 952 in **Figure 9b**).

In contrast to multimedia stream described by the histogram of **Figure 9e**, the multimedia stream described by the histogram illustrated in **Figure 9f** (the DVD for the movie "Species 1") requires significantly less buffering before playback. More particularly, as indicated in table 975, no pre-playback buffering is required at a bitrate of 5 Mbps. As such, if 5Mbps or more system bandwidth is available, playback may begin as soon as the stream reaches the multimedia node 151. In addition, in one embodiment, the allocation module 950 may initially allocate more bandwidth than required to fill the multimedia node buffer 920 during playback (e.g., so that more system bandwidth may be allocated elsewhere once the buffer is full).

In one embodiment, when a new playback stream is requested from a multimedia node 151, the allocation module 950 may initially allocate just enough system bandwidth to meet some minimum playback delay threshold. Thus, if this minimum delay threshold is set at 4.5 seconds, the allocation module 650 must allocate at least 7 Mbps to reproduce the multimedia content represented by the histogram of **Figure 9e** (see Table 970, 5<sup>th</sup> row). By contrast, to meet the minimum delay threshold for the multimedia content represented by the histogram of **Figure 9f**, the allocation module 950 may allocate a bitrate of















media network 140). The different decoding, encryption, and authentication features described above with respect to the cable broadcast module illustrated in **Figure 9** are also configured into one embodiment of the satellite module.

One embodiment of a cable modem for connecting the home media server 110 over a cable channel is illustrated in **Figure 12**. The cable modem includes a modulator unit 910, a Data Over Cable Service Interface Specification ("DOCSIS") module 920, and a data pump/PCI interface unit 930. Various different types of cable modems may be coupled to the home media server 110 while still complying with the underlying principles of the invention.

In addition to the encryption system described above, one embodiment of the system provides copyright protection through the use of copyright tags associated with content stored on the home media server 110. The tags of this embodiment identify which types of content/information may be copied or streamed to which multimedia devices. As illustrated in **Figure 13**, tags may be set to a variety of copy/playback levels, including, for example, a tag 1311 indicating no restrictions on copying for audio file 1310; a tag 1321 allowing only a single serial copy (e.g., to a CD-RW disk) with no copying to personal computers for audio file 1320; a tag 1331 permitting playback to local TVs (i.e., within the home media network 140) for video file 1330; and a tag 1341 allowing 24-hour playback to local TVs only (e.g., similar to a pay-per-view feature) for video file 1340. Accordingly, this embodiment provides an additional



mechanism for providing secure storage and transmission of copyrightable material. In one particular embodiment, content providers (e.g., cable and satellite providers) are provided with the ability to program tags into their content as necessary.

5           Embodiments of the present invention include various steps, which have been described above. The steps may be embodied in machine-executable instructions. The instructions can be used to cause a general-purpose or special-purpose processor, which is programmed with the instructions to perform certain steps. Alternatively, these steps may be performed by specific hardware  
10 components that contain hardwired logic for performing the steps, or by any combination of programmed computer components and custom hardware components.

          Elements of the present invention may also be provided as a computer program product which may include a machine-readable medium having stored  
15 thereon instructions which may be used to program a computer (or other electronic device) to perform a process. The machine-readable medium may include, but is not limited to, floppy diskettes, optical disks, CD-ROMs, and magneto-optical disks, ROMs, RAMs, EPROMs, EEPROMs, magnet or optical cards, propagation media or other type of media/machine-readable medium  
20 suitable for storing electronic instructions. For example, the present invention may be downloaded as a computer program product, wherein the program may



be transferred from a remote computer (e.g., a server) to a requesting computer (e.g., a client) by way of data signals embodied in a carrier wave or other propagation medium via a communication link (e.g., a modem or network connection).

5           Throughout the foregoing description, for the purposes of explanation, numerous specific details were set forth in order to provide a thorough understanding of the present system and method. It will be apparent, however, to one skilled in the art that the system and method may be practiced without some of these specific details. Accordingly, the scope and spirit of the invention  
10   should be judged in terms of the claims which follow.

09653964-090100